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Designing an effective RTO: Lessons from PJM (and elsewhere)

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What should a market do?

A well-functioning market provides a number of services:

- ***Allocate scarce resources*** **– e.g. transmission capacity**
- ***Creates feasible and efficient production schedules*** **– resolves constraint problems in advance**
- ***Creating efficient prices*** **– e.g. reflecting marginal costs**
- ***Coordinating activities*** **– should this unit be scheduled to provide energy output or spinning reserves?**
- ***Creates efficient incentives for operations and investment*** **– short-term and longer-term**
- ***Allows for hedging of risks*** **– Everyone is better off if risks are shared efficiently**

Markets

Energy and ancillary services trading

Forward energy trading (e.g. bilateral or auctions)

(One or more) day-ahead trading

Transmission trading

Forward transmission trading (e.g. FTRs or flow rights)

(One or more) day-ahead trading

Real-time trading (e.g. incs and decs) / Dispatch instructions

Time

Operations

UNIT COMMITMENT

UNIT DISPATCH

PJM provides a benchmark of the elements needed in an effective power market

Element needed		PJM approach
Forward trading	➡	**All forward trades are effectively financial – hub prices to create more liquidity**
Unit commitment – gen. scheduling ***(resolve dynamic and trans. constraints in day-ahead)***	➡	**Centralized unit commitment using bid start, energy and incr. costs and expected transmission constraints**
Ancillary services scheduling ***(which units scheduled for AS instead of energy)***	➡	**Units scheduled for AS in unit commitment – mainly paid for on an uplift basis**

Necessary elements of a power market - II

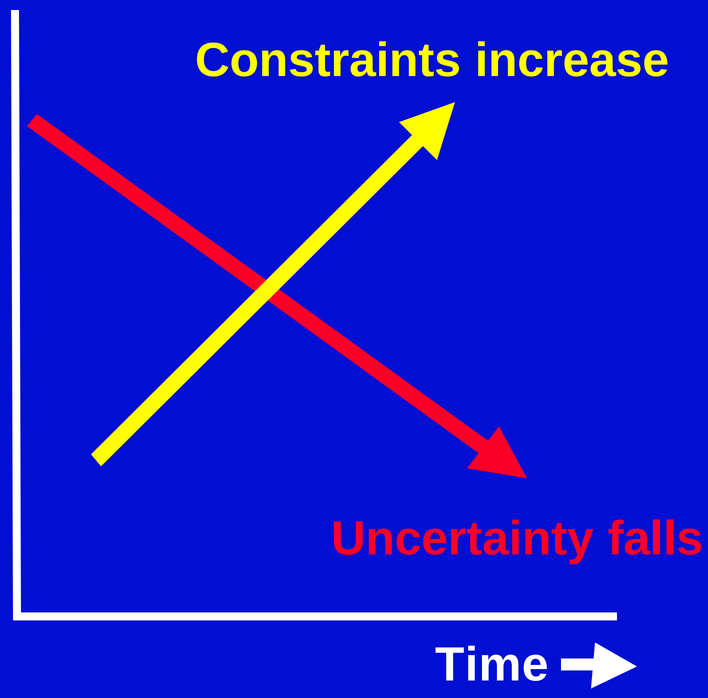
Element needed		PJM approach
Schedule new capacity in response to new conditions	➡	Supplemental unit commitment as needed
Short-run economic and reliability coordination	➡	Bid-based security constrained economic dispatch based on optimized LMP model
Hedging of risks	➡	Financial transmission rights to hedge price risks

Is the PJM design directly applicable to RTO West?

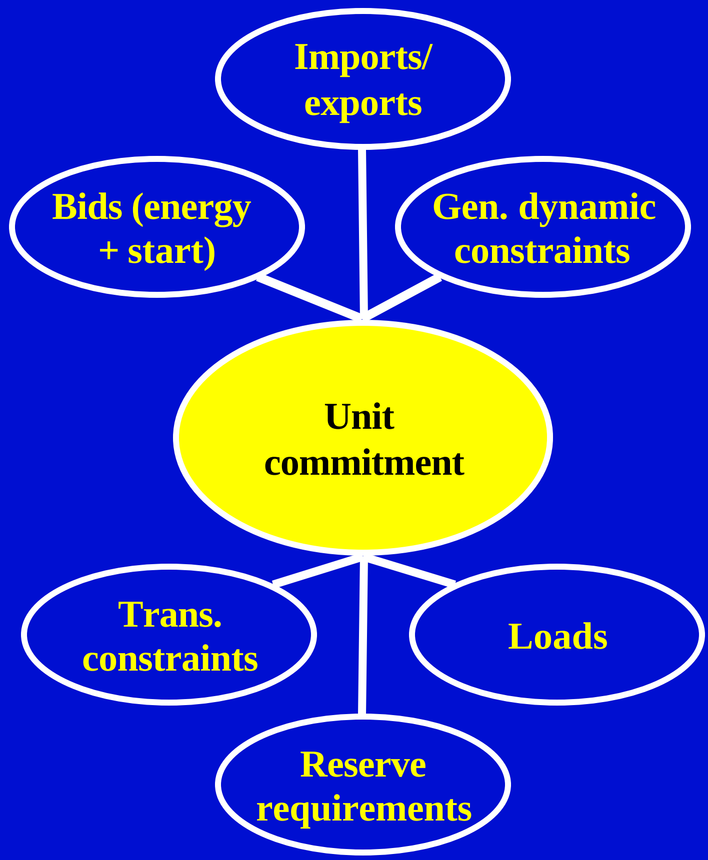
- PJM has benefited from an economically coherent approach – allows disparate elements to be integrated sensibly
- While the economic principles of all power markets are basically the same, market designs should reflect the physical realities of the system in question
- Many detailed elements of the PJM design reflect the nature of the physical and institutional factors that shape the market:
  - Predominantly thermal system with significant dynamic constraints
  - Substantial transmission congestion in many hours and in varying patterns
  - Long history as an integrated "tight pool"
- Message number one: Get the economics and design right, but make sure that you account for what drives your actual market

Forward Trading

- All transmission rights in PJM are financial – all forward trading is effectively financial
- Efficiency of forward trading depends critically on the quality of information
- For the Northwest, hydro is critical, and based on expectations of market on future supply and demand
- Forward price discovery in NE markets has been one of the weakest links (for a variety of reasons)
- Short-run liquidity is excellent, however, in bid-based systems
- *Forward price discovery is one area where the WSCC continuous bilateral model has served very well*



Unit commitment – dynamic constraints

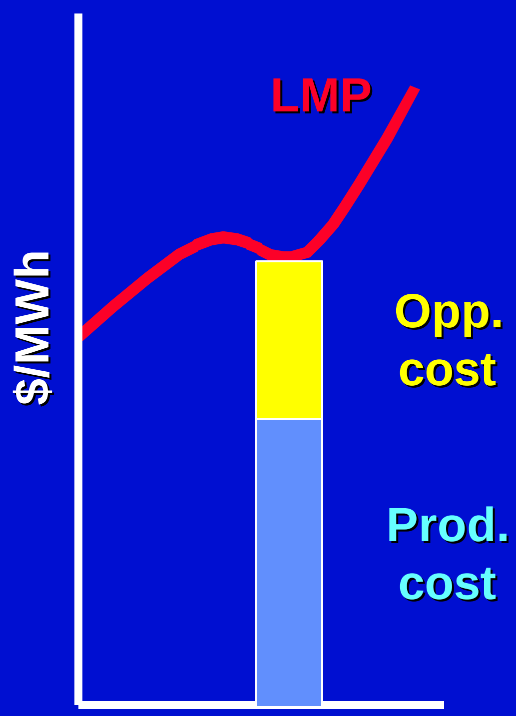


- **Dual focus in PJM in unit commitment – resolving dynamic constraints (start times, on and off-times, etc.) and transmission constraints**
- **Centralized optimization models used to crunch all the bids and see who should start, when they should start, etc.**
- **Production cost guarantee used to reimburse units told to start if energy prices do not justify their decision**
- ***Are these dynamic constraint as import in the PNW hydro environment?***
- ***If there are hydro dynamic constraints, can they be effectively modeled and optimized by the RTO?***

Unit commitment – trans. constraints

- **Transmission constraints resolved in PJM in unit commitment and schedules, and reflected in day-ahead LMPs**
- **Unless the system is almost entirely unconstrained and has plenty of flexible capacity, then there must be a market process for reaching these feasible schedules**
- **PJM does it with prices – so physical constraints can be reflected in software that is used to create LMPs**
- **Minimizes need to interact with participants over transmission capabilities (e.g. as in physical flowgate models), but possibly with some loss in transparency)**
- **Since all transmission is effectively controlled by operator, resolves market power concerns with no "release rules"**
- ***Message number two: Don't fall between the cracks of physical trading (e.g. need rights to schedule) and centralized commitment models. If day-ahead schedules are often not feasible then unwinding the problems creates large incentives for gaming (e.g. UK pool)***

Ancillary services scheduling and pricing



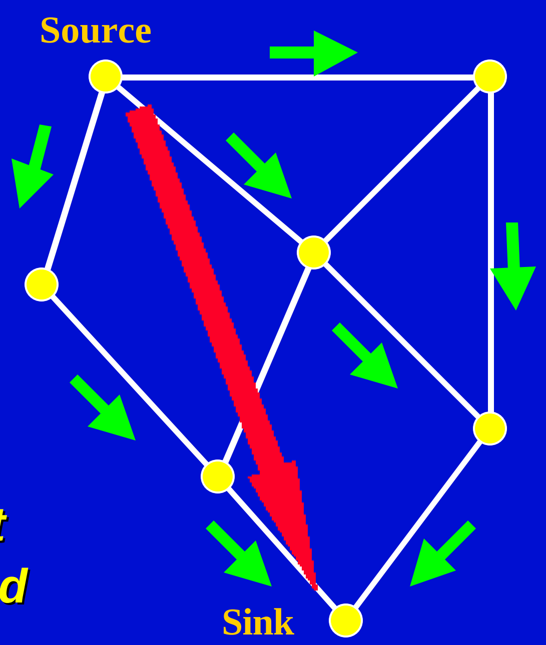
- **PJM picks units to provide reserves in central unit commitment**
- **Unlike other Northeast ISOs, PJM has not had separate market prices for spin, non-spinning reserves, etc.**
- **Energy and AS (e.g. spin) are complementary products for many units – need some way to coordinate. This can be done through “lost opportunity cost” payments or through entire bid AS markets**
- ***Costs of reserves may be less important in a hydro-oriented system. LOC difficult to determine for hydro units***
- ***Message number three: AS markets have not tended to work well. Proceed with caution.***

Short-run dispatch

- PJM LMP system, in which short-term constraints are reflected in real-time LMPs, has generally worked well
- Coordination is so complex at this timescale that quantity-based mechanisms may be ungainly or impractical
- Difficult to think of a better alternative unless the level of transmission constraints is very low, or if the level of vertical integration is so high that all constraints can be resolved within the portfolio. RT market in this case becomes very thin
- Market power concerns are always paramount in clearing single-shot auctions – by bidding a steep supply curve prices can be raised if demand turns out high with little volume risk
- *Clearing LMP-type mechanisms are more easily regulated – can compare supplier bids with calc. MC or even replace bids automatically (e.g. NYISO). Popular at FERC.*
- *Continuous auction mechanisms may prove more robust for day-ahead markets? Not likely to be practical in real-time*

Transmission risk hedging and rights

- **PJM FTRs are in keeping with the fundamental design – settling at spot prices allows all transactions to be financial**
- **Liquidity in FTR markets has probably been shaped more by external factors (e.g. retail regulation) than PJM design itself**
- ***Important differences in physical and financial models are philosophical – e.g. try to make the RTO "simple" through flowgates, and leave a lot of complexity to participants. But do the required PTDF stability conditions hold?***
- ***Financial approach is to internalize complexity into market optimization and simultaneous feasibility tests***
- ***Message number four: Either approach requires a focus on RTO regulation and incentives.***



Point-to-point FTR
vs.
Flowgate rights

Conclusions

- **PJM provides an excellent case study in market design. All of the necessary elements are there, and the design is based on a coherent economic framework.**
- **Markets are a means to an end. However designed, the basic functions need to be workable so that perverse incentives and outcomes can be avoided.**
- **While PJM has been the most successful of the existing ISOs, the circumstances of its development are very different than the WSCC. Many of the specific design elements of PJM are focused on the specific constraints of a thermal system.**